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VARIATIONS OF THE MAGNETIC FIELD AT HIGH LATITUDES AND STRUCTURE OF THE GEOMAGNETIC FIELD IN THE MAGNETOSPHERE

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SUMMARY

The magnetic field variations at high latitudes and the structure of the geomagnetic field in the magnetosphere are discussed in the light of equatorial boundaries of oval aurora zone, of westerly current vortex and of the equivalent current system DPC during IGY.. Reference is also made to the three mechanisms responsible for the magnetic disturbance in the near-polar region [23]. It is suggested that one of them is responsible for rapid phase variations of the perturbed vector, the other two for the appearance of DPC current system.

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According to contemporary representations, the Earth's magnetosphere is formed as a result of interaction of solar corpuscular radiation with the geomagnetic field. The action of solar plasma fluxes leads to the appearance of normal and tangential pressures upon the plasma, frozen in the magnetic field of the Earth. The former determines the formation of the geomagnetic cavity, a and the latter the formation of the geomagnetic tail. Therefore, there are on both the daytime and nighttime sides of the Earth closed lines of force suggesting a dipole field, and lines of force of Earth's magnetic tail, extending over great distances in the antisolar direction.

Satellite observations confirmed such geomagnetic field structure [1, 2], forecast theoretically in [3]. At high latitudes there are formed on the day side of the Earth two neutral points, one in each hemisphere, which correspond to geomagnetic latitudes, defining the boundary of the two types of lines of force, namely those closing on the daytime side and those carried in the tail.

The region of neutral points offers a great interest from the standpoint of geophysical events at high latitudes, as a possible place of injection inside the magnetosphere of energetic charged particles [4].

The presence within the magnetosphere of two nature-wise different regions of the geomagnetic field determines the development of magnetic disturbances at high latitudes. It was shown in [5 – 7] that an intense ionospheric current flows along the boundary of closed lines of force in a westerly direction.

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[*] VARIATSII MAGNITNOGO POLYA V VYSOKIKH SHIROTAKH I STRUKTURA GEOMAGNIT NOGO POLYA V MAGNITOSFERE

The position of the electrojet coincides with the region of intrusion into the ionosphere of electrons with E > 10 kev, inducing the appearance of polar aurorae along the oval zone [8]. As the intensity of polar magnetic disturbances increases (DP), so does the region encompassed by the western electrojet.

Plotted in Fig.1 is the position of the equatorial boundary of aurora oval zone according to [9] (solid line) and of the western electrojet (dashed line) for the northern hemisphere and different K_p. The position of the electrojet was determined from the analysis of the space-time distribution of the perturbed sector in the horizontal plane for the period November 1957- Feb.1958 [10]. The dashed line defines the latitudes at which the value of ΔT constitutes 20 percent of the extreme value of the field at the corresponding hour. It may be seen that the western electrojet is disposed within the bounds of the oval zone of aurorae and their equatorial boundaries just about coincide, except for the evening sector. As K_p rises, the boundary of such a current jet shifts monotonically toward the equator at all longitudes, just as the oval aurora boundary which corresponds to a shift toward lower and lower latitudes, i. e. to smaller L, the boundary of closed lines of force of the geomagnetic field and the boundaries of the region of capture of energetic electrons. Satellite observations of the position of the boundary of trapped electrons' region have shown that as Kp increases, the boundary of the radiation belt does indeed shift to lower latitudes (see [11–13].

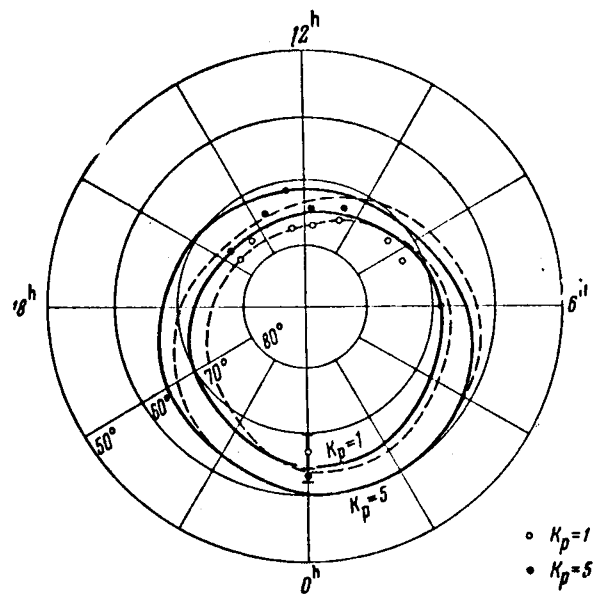

Fig.1. Equatorial boundaries of oval aurora zone after [9] (solid lines) and of current vortex of westerly direction (dashes) at $K_p = 1$ and $K_p = 5$

The clear and dark circles are the equatorial boundaries of appearance of magnetic disturbances after satellite data [14,15] at 1100 km, respectively for $0 \leqslant K_p \leqslant 1$ and $4- \leqslant K_p \leqslant 5+$. For night hours the mean quadratic deviation is shown according to [14]. The coordinates are the corrected geomagnetic latitude and the local GM time

Plotted in Fig.1 is also the equatorial boundary of the region, where according to satellite 1963 38 C data, with motion along a polar orbit at 1100 km, there regularly appeared magnetic disturbances in the form of oscillations of a magnetic field of intensity from a few tens to several hundred gammas [14, 15]. These irregular oscillations are observed along the oval boundary of aurorae at all longitudes, but somewhat closer to the pole. Apparently, as the hot plasma moves beyond the region of steady trapping, hydromagnetic waves are generated, propagating toward the Earth along the lines of force. As Kp increases, the northern and southern boundaries of latitude interval in which irregular magnetic oscillations are observed from the satellite, shift toward the equator. A similar singularity in boundary shift takes place for the aurora oval at daytime side [16]. The shift toward the equator of the regions of active geophysical events with increased geomagnetic activity may be evidence of change in configuration of the geomagnetic field, and, in particular, of a shift of neutral points on the daytime side of the Earth toward lower latitudes.

The continuous plasma injection through the neutral points apparently conditions the existence in the near-polar region of magnetic disturbances occuring in the summer season even in the most magnetoquiet days [17, 18]. These disturbances, classified in [19] as permanent, appear mostly during daytime hours local time and are characterized by notable seasonal variations with maximum during the summer solstice. Moreover, a high level of short-period oscillations is characteristic of these disturbances; these are superimposed to the smooth variations of the magnetic field in the near-polar region and are determined by its mean-hourly values. The equivalent current system of magnetic field variations in the near-polar region according to universal magnetoquiet days was first proposed in [20], but without any accounting or estimate of the influence of DP disturbances upon the shape of the obtained current system. On the basis of analysis of magnetic field observations in high latitudes on quiet days of the summer of IGY, an equivalent current system was obtained in [21], which was different from that of [20] and responsible for the variations of the magnetic field in the near-polar region, whereupon the effect of the western electrojet was excluded.

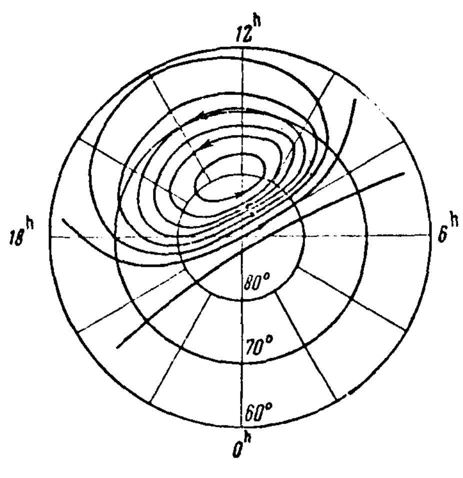

Fig.2. Equivalent current system DPC for IGY's solar solstice & magnetoquiet periods. There are 5000 amp between current lines

We plotted in Fig.2 the current system according to the quiet days of IGY summer after excluding all periods when positive or negative DP were observed on magnetograms of observatories with $\Phi < 70°$. It consists of a single-vortex situated on the daytime side of tne Earth with counterclockwise direction of currents and a focus on $\Phi \sim 80°$ on the 13-hour meridian, and is analogous to the current system of [21]. The current system of Fig.2 characterizes the disturbances of the magnetic field in the polar cap, i. e. DPC. The DPC current intensity in summer season varies from $4 \cdot 10^4$ for particularly quiet periods, to $1.7 \cdot 10^5$ during magnetic disturbances with $K_p = 5$, when DPC constitute a composing part of S - variations at high latitudes. As the disturbance increases, the focus of DPC current system shifts toward the afternoon hours. It is apparently difficult to explain the single-vortex current system of DPC by a system of convective motions in the magnetosphere of the type [22]. It corresponds better to closed current circulation in the ionosphere, analogous to motion of magnetosphere matter about a neutral point, which is situated in exclusively quiet days on $\Phi \sim 80°$. Three mechanisms are proposed in [23], which are responsible for the magnetic disturbance in the near-polar region: the arising of instabilities at magnetosphere boundary, forming hydromagnetic waves that propagate along the lines of force passing through the neutral point; the injection of charged particles in the region of the neutral point; the motion of lines of force forming the surface of the magnetosphere, relative to rotating Earth. The first mechanism may explain the rapid phase variations of the perturbed vector for short time periods. The second and the third mechanisms are possibly responsible for the appearance of the DPC current system.

***** THE END *****

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